RESEARCH DEPARTMENT

The pulse response of some domestic u.h.f. television receivers, and its relation to the amplitude and group-delay characteristics

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THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

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SUMMARY

The responses of seven domestic monochrome television receivers to a u.h.f. signal modulated with a 2T pulse-and-bar waveform, have been measured, and the corresponding routine K-ratings derived. For two receivers the static amplitude and group-delay characteristics were measured, using a technique permitting independent measurements for the upper and lower sidebands. In both cases the pulse response shape computed from these characteristics compared well with that measured directly, but less agreement was obtained in the case of the pulse-to-bar ratios.

1. INTRODUCTION

For certain aspects of planning a television broadcasting service, it is desirable to have some quantitative information on the performance of a typical domestic receiver. In particular, it is necessary to be able to assess the effect of any changes which may be made in the shape of the transmitter filter characteristics. Such changes may be necessary, for example, at stations radiating in a band adjacent to one used for radio astronomy measurements. In assessing the resulting receiver performance, it is useful to know its response to a 2T pulse, and the routine K-rating.[1] The K-rating is widely used by authorities concerned with the distribution and transmission of television signals, but there appears to be little information concerning its application in evaluating the performance of domestic receivers.

K-rating was evolved for giving an approximate measure of the subjective effect of distortions in linear systems. The presence of non-linearities (including that due to envelope detection of a vestigial sideband signal) may reduce its validity, but it is still considered useful.

The routine K-ratings corresponding to the distortion of the 2T pulse, and the pulse-to-bar ratios were measured on seven monochrome receivers, working in the u.h.f. band on the U.K. 625-line standard (Standard 1). Although this is a small sample, it is thought that the results can be regarded as fairly typical of those obtained on receivers in current use. The measurements were compared, in two cases, with values computed from measurements of the steady-state amplitude and group-delay characteristics, with the object of assessing the reliability of such predictions in practical receivers.

The technique employed for the steady-state measurements permitted the characteristics at the upper and lower i.f.* sideband frequencies to be found separately. It also permitted alternative sets of measurements to be made, one applicable to circuits up to the detector only and the other giving the overall response including the combined effects of these circuits and the video amplifier. From these measurements it is possible to assess the so-called quadrature-distortion term that arises with envelope detection, and to include any subsequent distortion at video. The calculation of the pulse response took the quadrature distortion into account but ignored any other source of non-linear distortion in the receiver.

2. MEASUREMENT TECHNIQUES

2.1. 2T Pulse Responses

A block diagram of the experimental arrangement for measuring the pulse response is shown in Fig. 1.

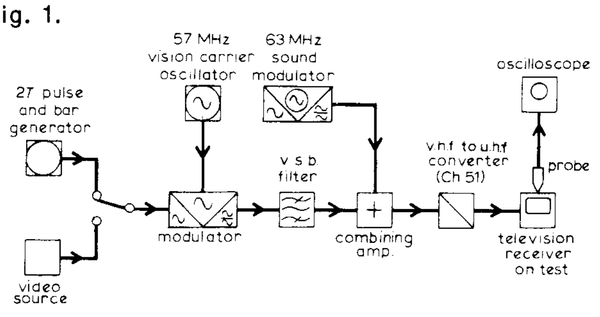


Fig. 1 - Arrangement for measuring 2T pulse responses

* In this report, the term 'i.f.' is assumed to include the effects of the r.f. circuits.

The video test signal was arranged to modulate a vision carrier at 57 MHz, using negative modulation to accord with the 625-line Standard I, the modulation depth being such as to allow a 20% residual carrier at the peak (white level) of the video signal. The modulated carrier was then fed through a vestigial sideband (v.s.b.) filter, which had a characteristic in the region of the vestige approximately similar to that of u.h.f. television broadcast transmitters. The output from the filter was combined with a frequency-modulated sound carrier at 63 MHz, and fed to a frequency changer which converted the combined signals to u.h.f. Channel 51.

The amplitude response of the modulator and v.s.b. filter, from −1·25 MHz to +5·5 MHz relative to the vision carrier frequency, was uniform to within ± 0·2 dB, and the group delay to within ± 20 ns. It was assumed that the v.h.f. to u.h.f. converter introduced a negligible degradation of the response.

For tuning the receivers, the video signal fed to the modulator was obtained by demodulating a normal broadcast transmission in a high-grade laboratory receiver. The sound modulation was also obtained in this way. Using this picture modulation, the receiver under test was tuned to give the most pleasing picture, consistent with a reasonably satisfactory sound signal. This probably represents the method of tuning used in practice on the majority of domestic receivers.

The video waveform appearing at the cathode of the receiver cathode-ray tube was applied, via a high-impedance probe, to a wide-band oscilloscope provided with a standard graticule for measuring the K-rating. The responses to both positive and negative pulses were measured.

2.2. Amplitude and Group-Delay Characteristics

A block diagram of the arrangement for measuring the amplitude and group-delay characteristics is shown in Fig. 2. The v.h.f. test oscillator was varied in frequency over a range of −2 MHz to +5·5 MHz relative to the vision carrier frequency (57 MHz in this case), and the output was modulated by a fixed-frequency 30 kHz sine wave in a suppressed-carrier modulator. The vision carrier frequency was available from a separate oscillator, and it could be added, when required, before the signal was applied to the converter. A fixed a.g.c. voltage from a battery was applied at a suitable point in the receiver in order to stabilize the gain. The video-frequency voltage appearing at the cathode of the receiver cathode-ray tube was applied, via a high-impedance probe, to the 'Y' amplifier of a wide-band oscilloscope, while the 'X' time-base was triggered from the 30 kHz modulating source. The types of display produced on the oscilloscope are illustrated in Fig. 3.

In Fig. 3(a), the vision carrier frequency has been added, so that as the frequency of the test oscillator is varied, a varying video beat frequency within the 30 kHz envelope is transmitted through the receiver video amplifier and the overall response displayed on the oscilloscope includes the effect of the video amplifier frequency response. In Fig. 3(b), the vision carrier has not been added, so that the only component transmitted through the video amplifier is the detected 30 kHz modulation envelope. In this case the change of delay with variation of input frequency, and hence the display, is affected by the i.f. (and r.f.) frequency response alone. By taking the difference between the i.f. response and the overall response, the video amplifier response could be deduced.

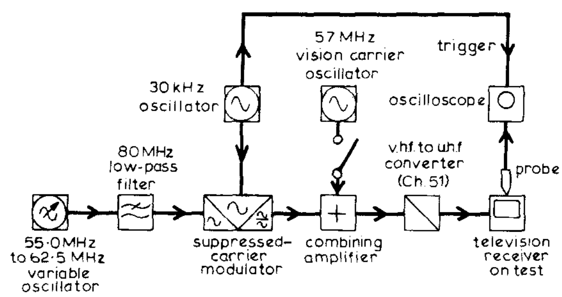
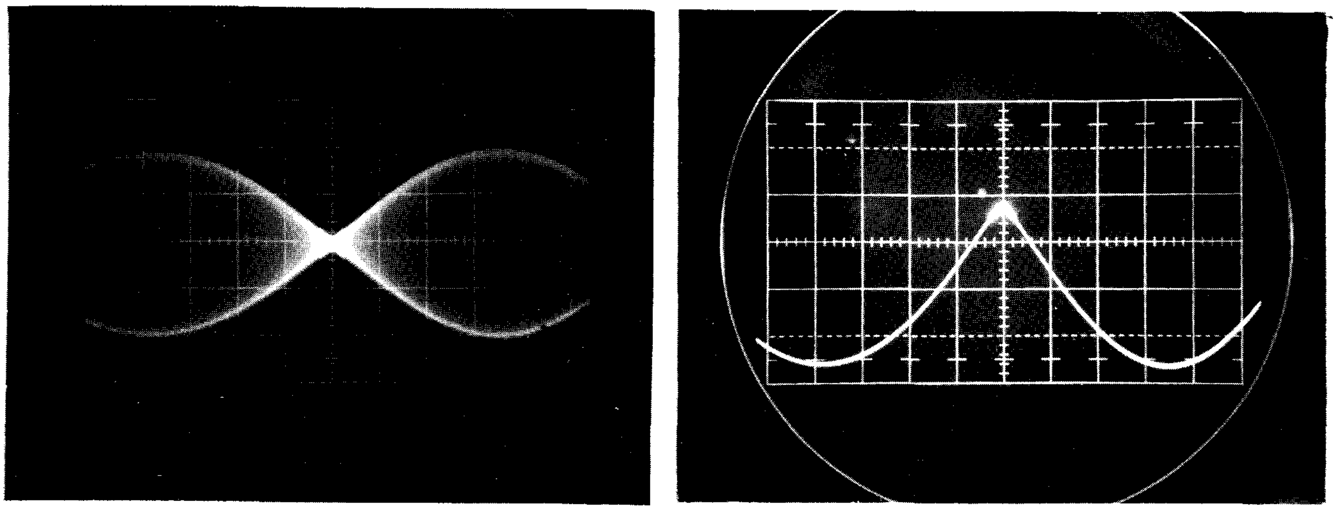


Fig. 2 - Arrangement for measuring amplitude and group-delay characteristics

The amplitude response corresponding to a given frequency from the test oscillator was measured by finding the amplitude of the displayed modulation envelope. The relative group delay was obtained by measuring the horizontal shift of the sharp cusp in the waveform, relative to a convenient arbitrary position. On the particular oscilloscope used (a Tektronix 547), it was found convenient to use the 'B intensified by A' bright-up as a marker, and the calibrated trigger delay control as the measure of delay. Using this method, the relative group delay could be measured with an accuracy of ± 20 ns. The measurements were performed at 0·25 MHz intervals.

This technique facilitates measuring the separate delays of the upper and lower sidebands corresponding to a given video modulating frequency, even when access is only possible at the input and output of the receiver. The effects of the probe when measuring the i.f. response are much smaller than if it were introduced directly into tuned amplifier circuits. The technique also avoids the problem concerning the correct point at the detector input at which to place the probe; this is sometimes difficult to decide, because at the detector the performances of the i.f. and v.f. circuits are mutually dependent.



(a) (b)

Fig. 3 - Oscilloscope display for measuring amplitude and group-delay characteristics

(a) with vision carrier (b) without vision carrier

Apart from investigating the contributions to distortion within a receiver, information concerning the separate side-band characteristics is required, for example, when estimating the change in the receiver response caused by adjustments to r.f. filters at the transmitter which may modify the amplitude and phase of the two sidebands to a different extent. A discussion of such adjustments is not pertinent to this report, but the measuring technique was developed partly with this requirement in mind. The necessary information would not be provided by measuring the overall video amplitude response and group delay from the input of a modulator to the output of the receiver.

In general, the calculation of the pulse response from the static characteristics should be carried out in two stages, viz.,

(i) The shape of the modulated i.f. envelope is first found, taking into account the two separate sideband characteristics (Fig. 3(b)),

and (ii) the resultant time function of this envelope is then subjected to the v.f. amplifier characteristic to obtain the overall pulse response.

In many cases, only a small error occurs if the response is calculated assuming that the v.f. amplifier has a flat amplitude characteristic and a constant group delay, using the method of Fig. 3(a).

3. RESULTS OF MEASUREMENTS

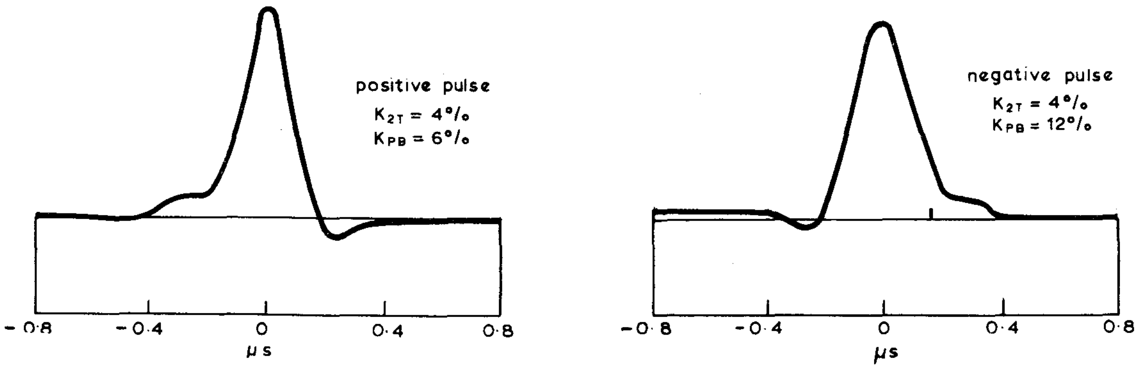
3.1. 2T Pulse and K-Rating

The seven receivers tested will be referred to as receivers A to G. The pulse responses obtained are shown in Fig. 4, together with the corresponding K-ratings based on the pulse shape, and the pulse-to-bar ratio. (Other criteria, such as the droop of the bar, were not measured). In Fig. 4, the negative-going pulses have been inverted to positive-going, for ease of comparison.

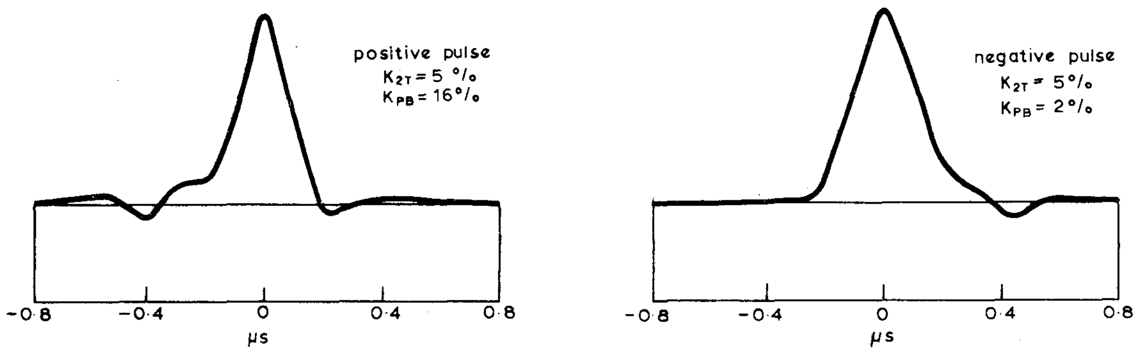
There is some difference between the shapes of the positive and negative pulses, but no significantly consistent trend can be observed when all the results are considered. Taking the arithmetic mean of the figures, the ratings obtained are

	pulse shape	pulse-to-bar ratio
positive pulse	6·4%	6·6%
negative pulse	6·6%	5·0%

This represents a subjective grading of approximately 0·65, using the scale proposed by Prosser et al;[2] i.e., the quality is between fair and good.



RECEIVER A



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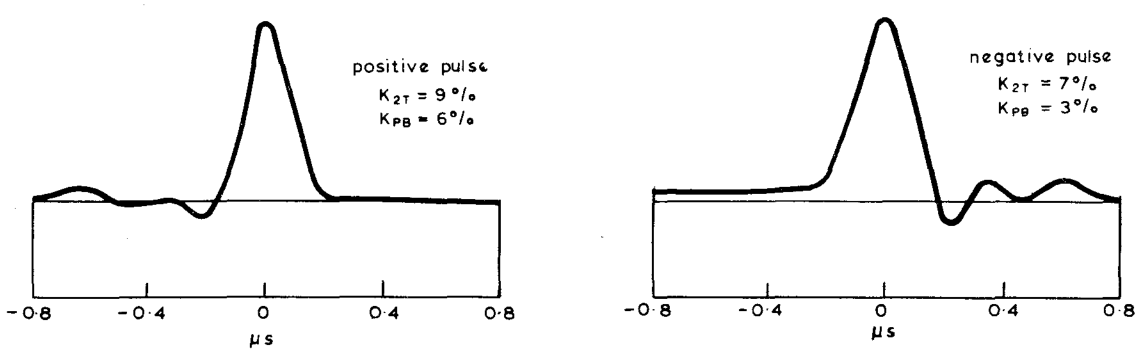
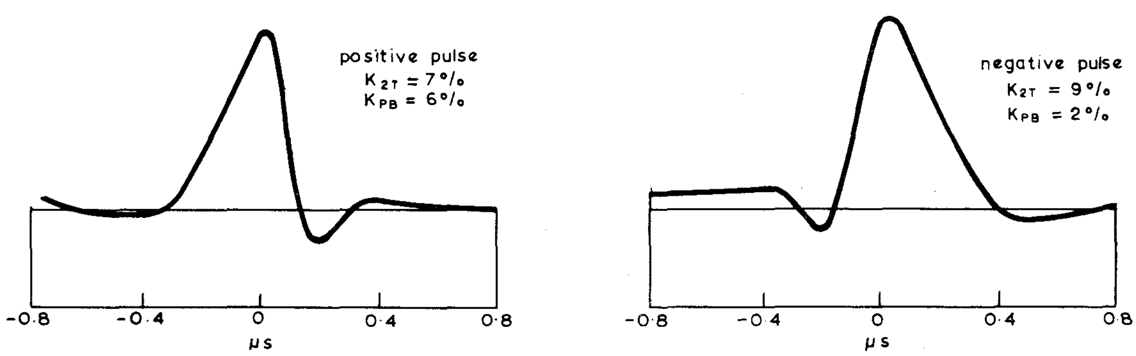


RECEIVER C



RECEIVER D

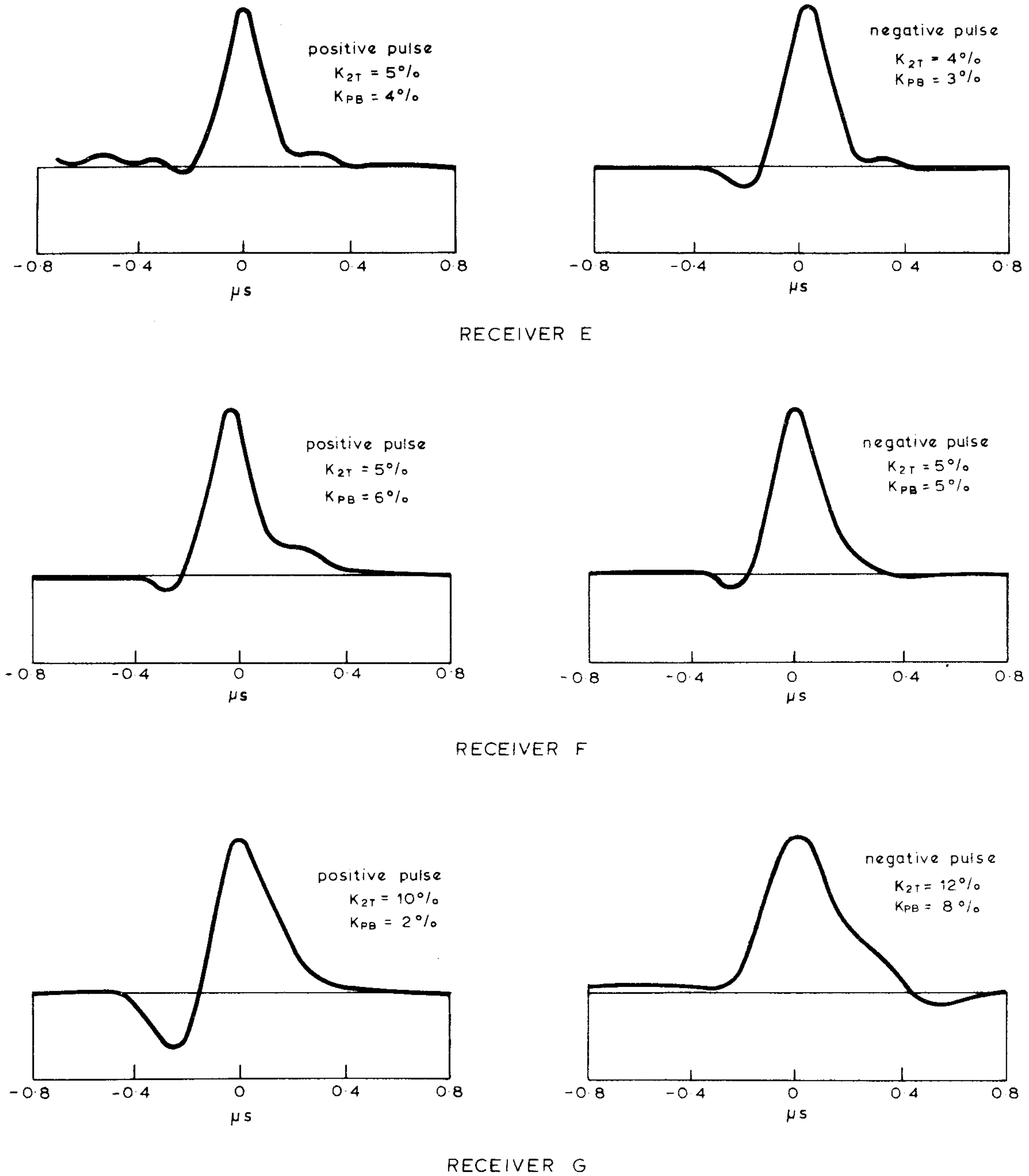


Fig. 4 - 2T pulse responses

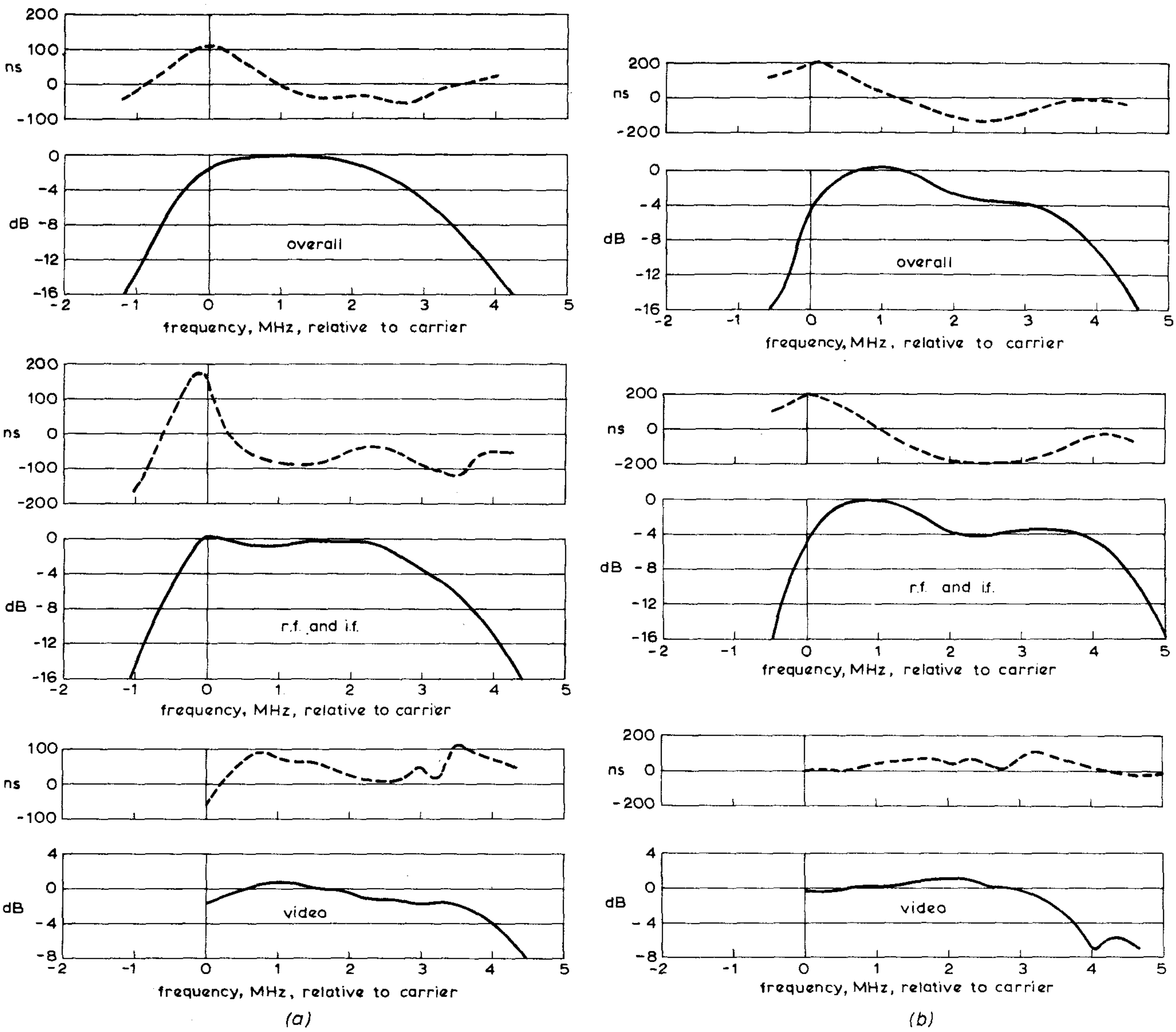


Fig. 5 - Amplitude and group-delay characteristics
(*a*) Receiver A (*b*) Receiver G

——— Amplitude - - - - - - Group delay

3.2. Comparison between Predicted and Measured Pulse Responses

The steady-state amplitude and group-delay characteristics were measured on receivers A and G, and the results are shown in Fig. 5. The overall responses were obtained, and also the responses of only the i.f. circuits, as described in Section 2.2. In each case the video amplifier characteristic was deduced by taking the difference between the two sets of measurements. The video characteristics so obtained are not very accurate, but they illustrate that the video stages may have a significant effect on the overall performance.

The 2T pulse responses corresponding to the overall measured steady-state characteristics were computed, both for positive-going and negative-going pulses. In the case of the negative pulses, the computation was carried out (*a*) by including only the i.f. characteristics in the quadrature-distortion calculation, followed by a calculation of the effect of the video response on the resulting pulse shape, and (*b*) by applying the quadrature-distortion calculation to the overall characteristics. The difference between the K-ratings of the two cases was small, and could be accounted for by possible errors in deducing the response of the video amplifier. Therefore, although method (*a*) is more correct in principle, it was more convenient, and for these particular measurements equally accurate, to use method (*b*).

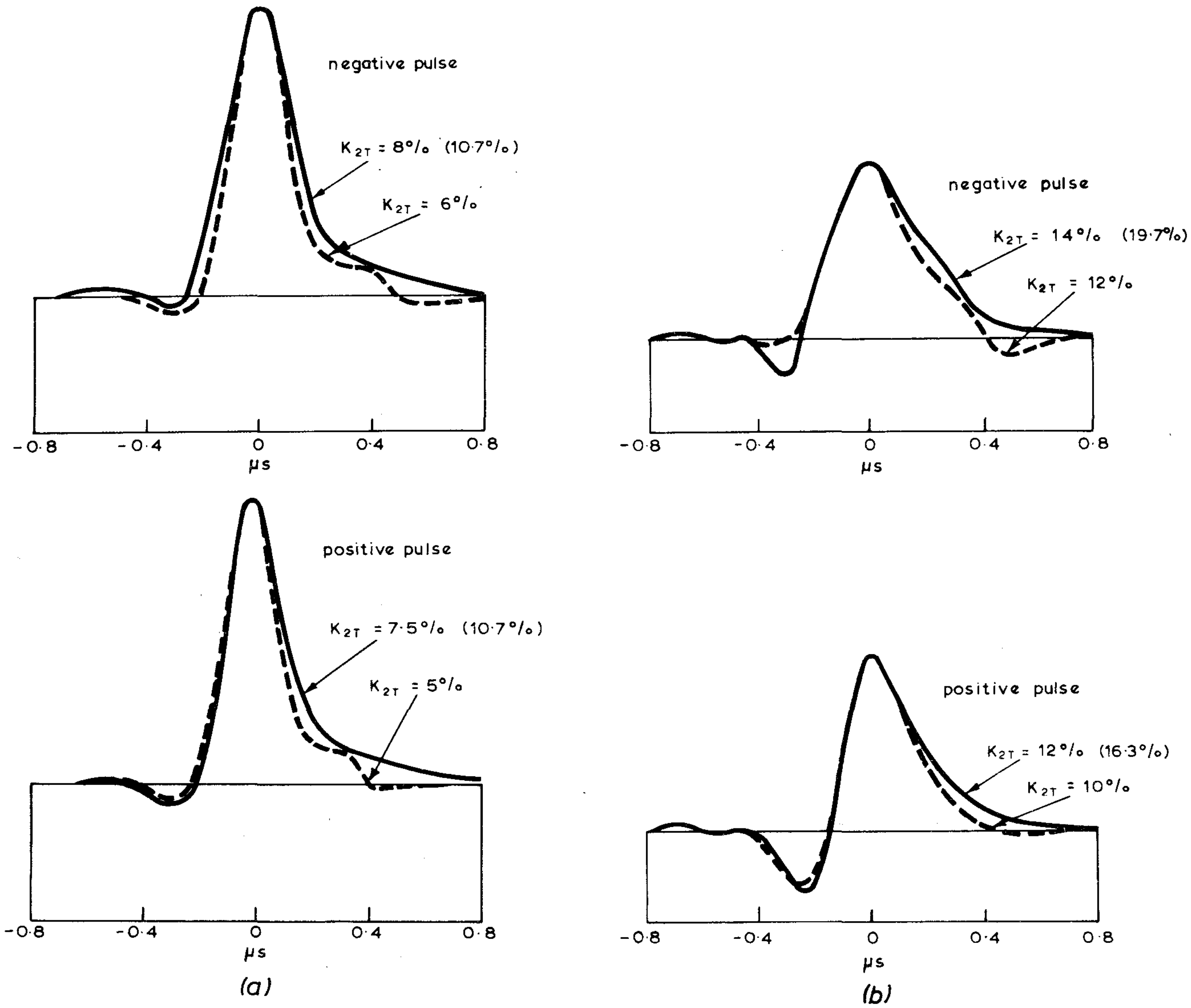


Fig. 6 - Comparison of measured and computed 2T pulse responses
(*a*) Receiver A (*b*) Receiver G

———— Computed - - - - - Measured

The computed pulse responses were compared with those measured as discussed in Section 2.1. The results are shown in Fig. 6. There is reasonably good agreement between the computed and measured pulse shapes. Poor agreement was found in the case of the pulse-to-bar ratios. This is probably because the computation assumed that the low-frequency response is maintained down to zero frequency, whereas the measured pulse-to-bar ratio is sensitive to deficiencies in low-frequency response.

To find the effect of the video amplifier upon the pulse shape, the pulse response was computed assuming that the video amplitude and group-delay characteristics were perfectly flat. The corresponding K-ratings are given in brackets, in Fig. 6. In each case the K-rating is worse, so that the apparent imperfections in the video characteristics counteract those in the i.f. characteristic, resulting in an overall improvement in performance. In particular, the droop in the low-frequency response of the video amplifier tends to correct for the vision carrier being less than 6 dB down on the slope of the i.f. characteristic in the preferred tuning position for the receivers employed. This is understandable since the receiver is tuned initially for optimum overall performance judged on a picture.

4. CONCLUSIONS

The 2T pulse responses and the pulse-to-bar ratios of some typical domestic monochrome u.h.f. television receivers have been measured. The mean routine K-rating corresponding to these measurements is about 6%. The amplitude and group-delay characteristics of two of the receivers were also measured, and the pulse response deduced, taking quadrature distortion into account. The agreement obtained with the measured pulse shape in these two cases indicates that, in practice, forms of non-linearity other than that due to quadrature distortion do not significantly affect the calculation of the corresponding K-rating from the steady-state characteristics. The prediction of the pulse-to-bar ratio was, however, subject to a fairly large error.

The steady-state measuring technique employed permitted the upper and lower i.f. sideband characteristics of a receiver to be measured independently; a knowledge of these is useful for assessing the effects which might occur in the event of changes in the transmitting v.s.b. filter characteristics.

5. REFERENCES

1. LEWIS, N.W. 1954. Waveform responses of television links. *Proc. Instn. elect. Engrs.*, Pt. III, July 1954, **101**, 72, p.258.

2. PROSSER, R.D., ALLNATT, J.W. *and* LEWIS, N.W. 1963. Quality grading of impaired television pictures. *Proc. Instn. elect. Engrs.*, March 1964, **111**, 3, p.491.

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